Status of NOvA

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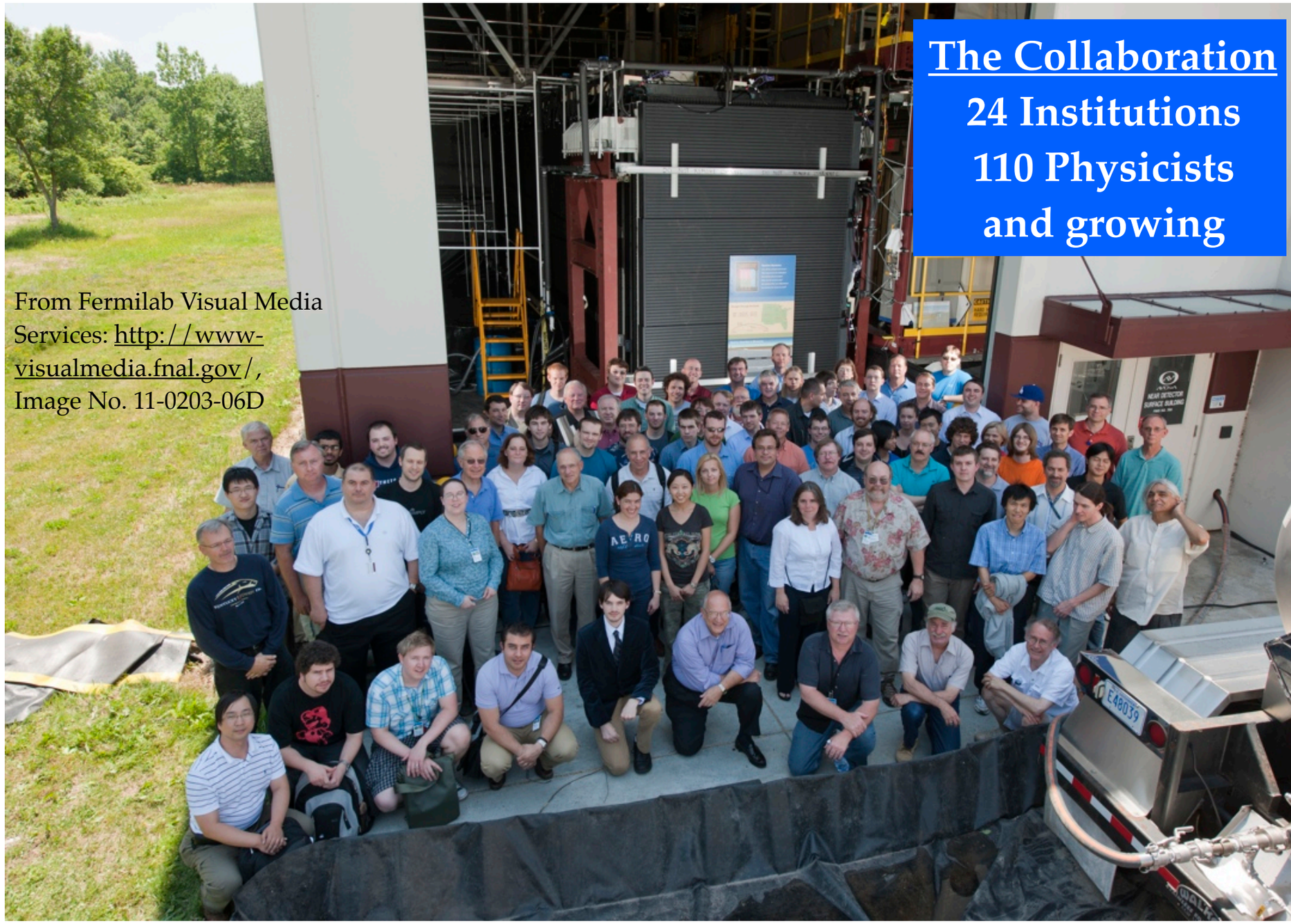
Advances in Neutrino Technology
Philadelphia, PA - 2011 Oct. 10

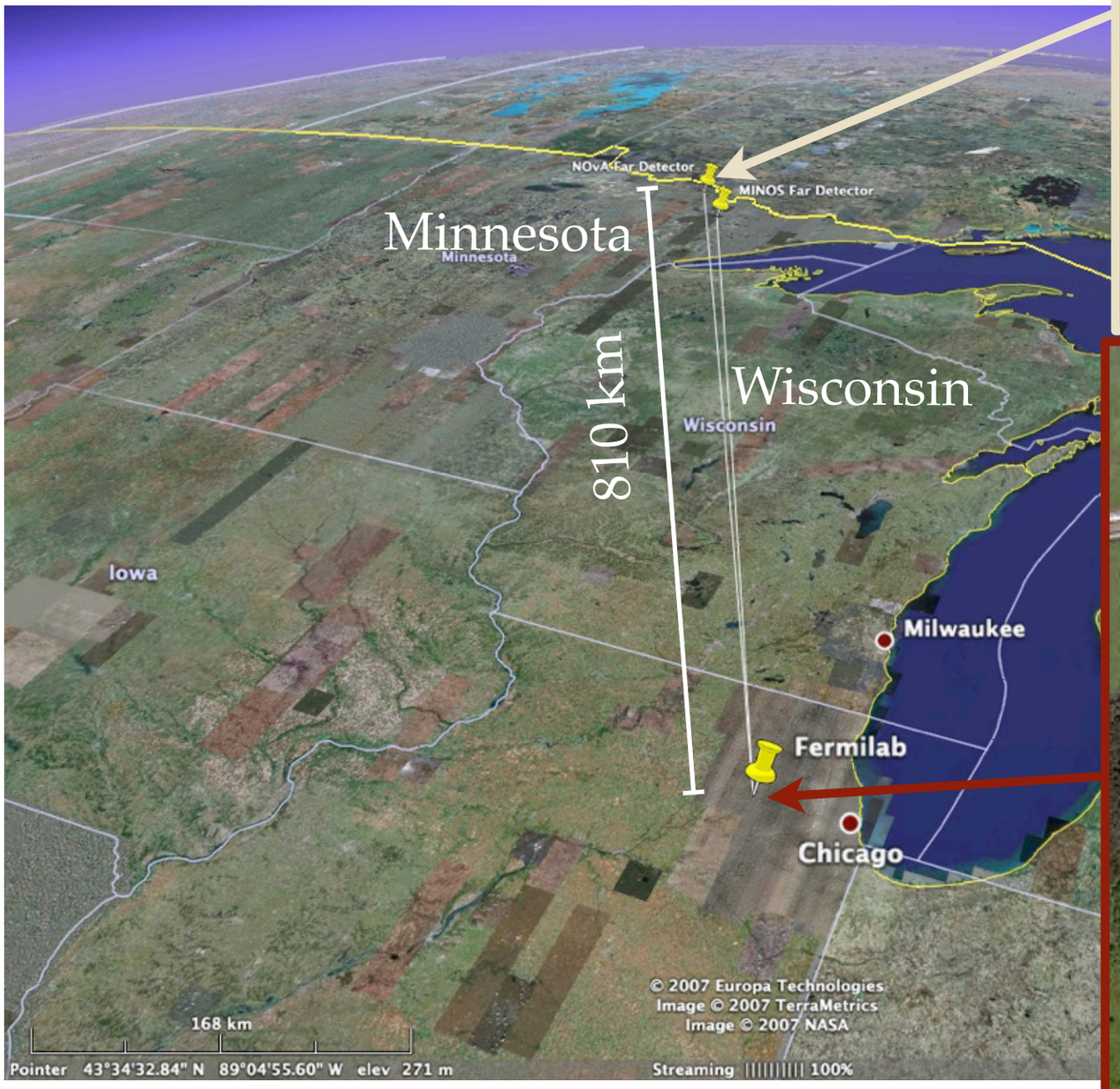
Outline

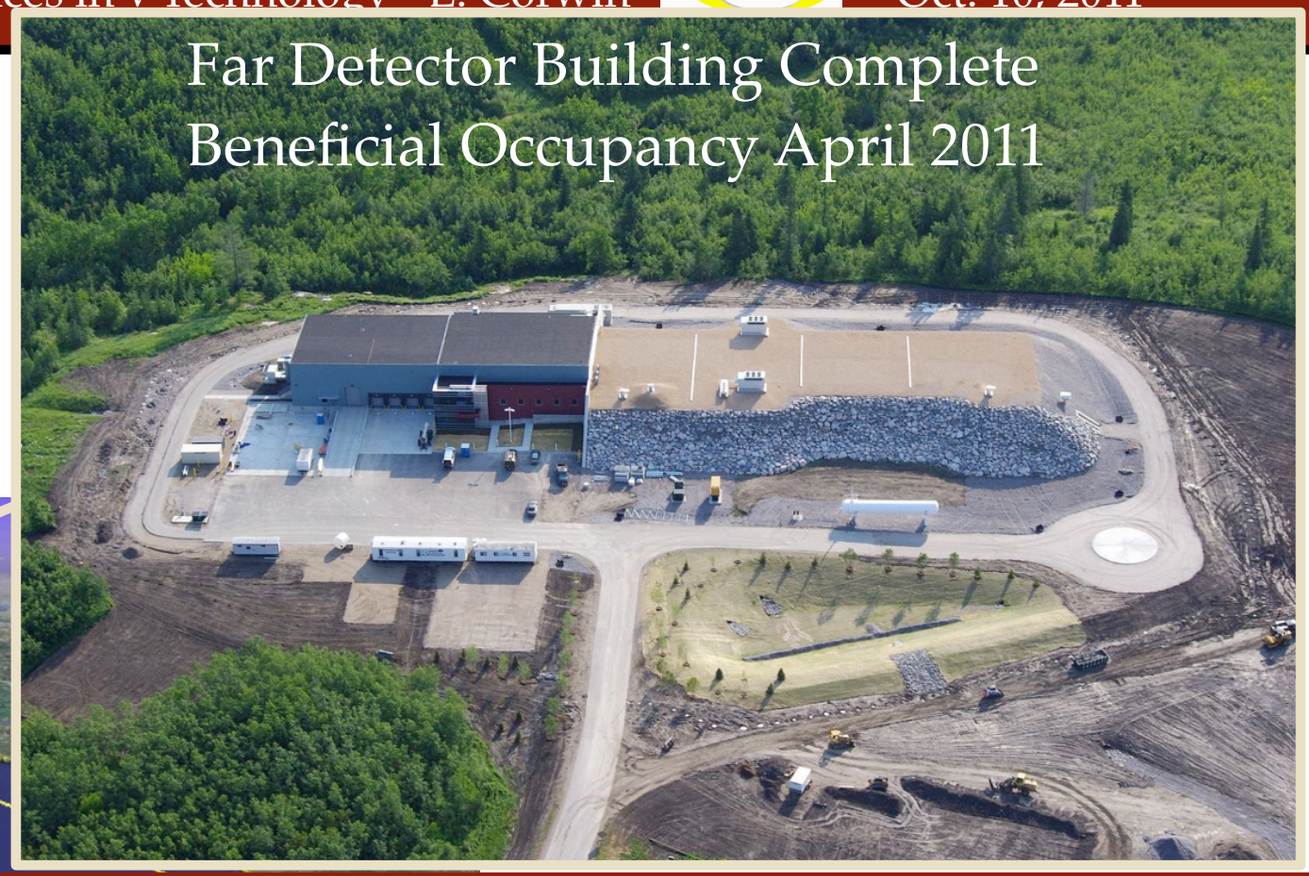
- Brief Experimental Overview
- Scintillator
- **PVC Extrusions**
- **Avalanche Photodiodes (APDs)**
- Schedule



ANL, Athens, Caltech, Institute of Physics of the Czech Republic, Charles University, Czech Technical University, FNAL, Harvard, Indiana, Iowa State, Lebedev, Michigan State, Minnesota/Duluth, Minnesota/Twin Cities, INR Moscow, South Carolina, SMU, Stanford, Tennessee, Texas/Austin, Tufts, Virginia, WSU, William and Mary

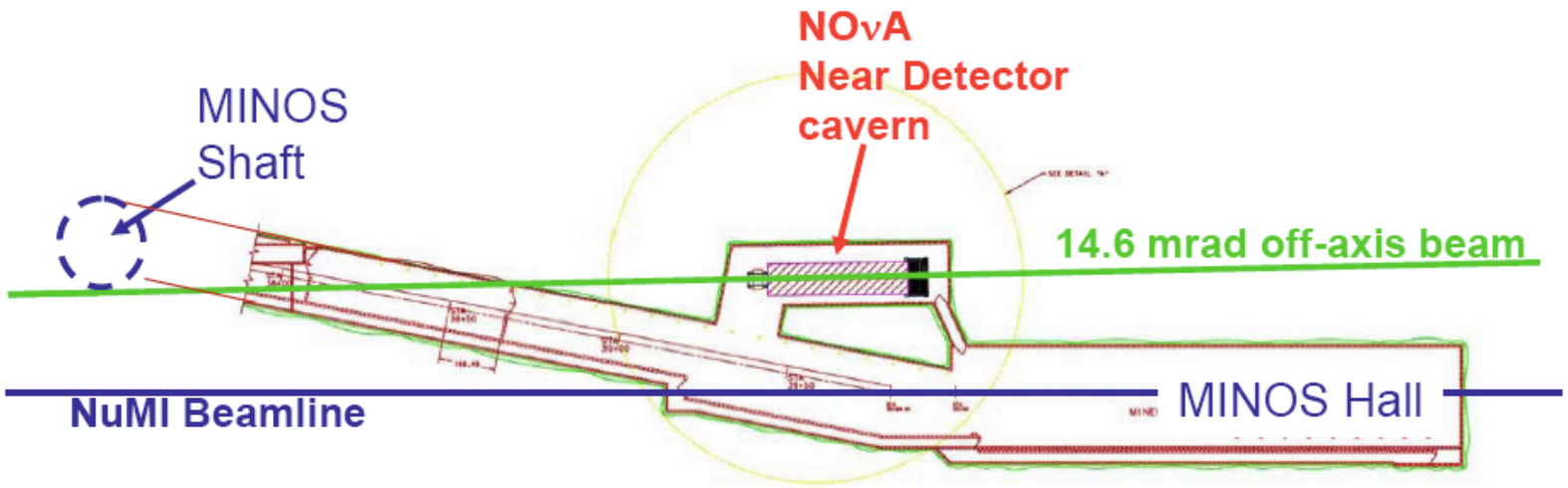
NOvA Experiment Overview



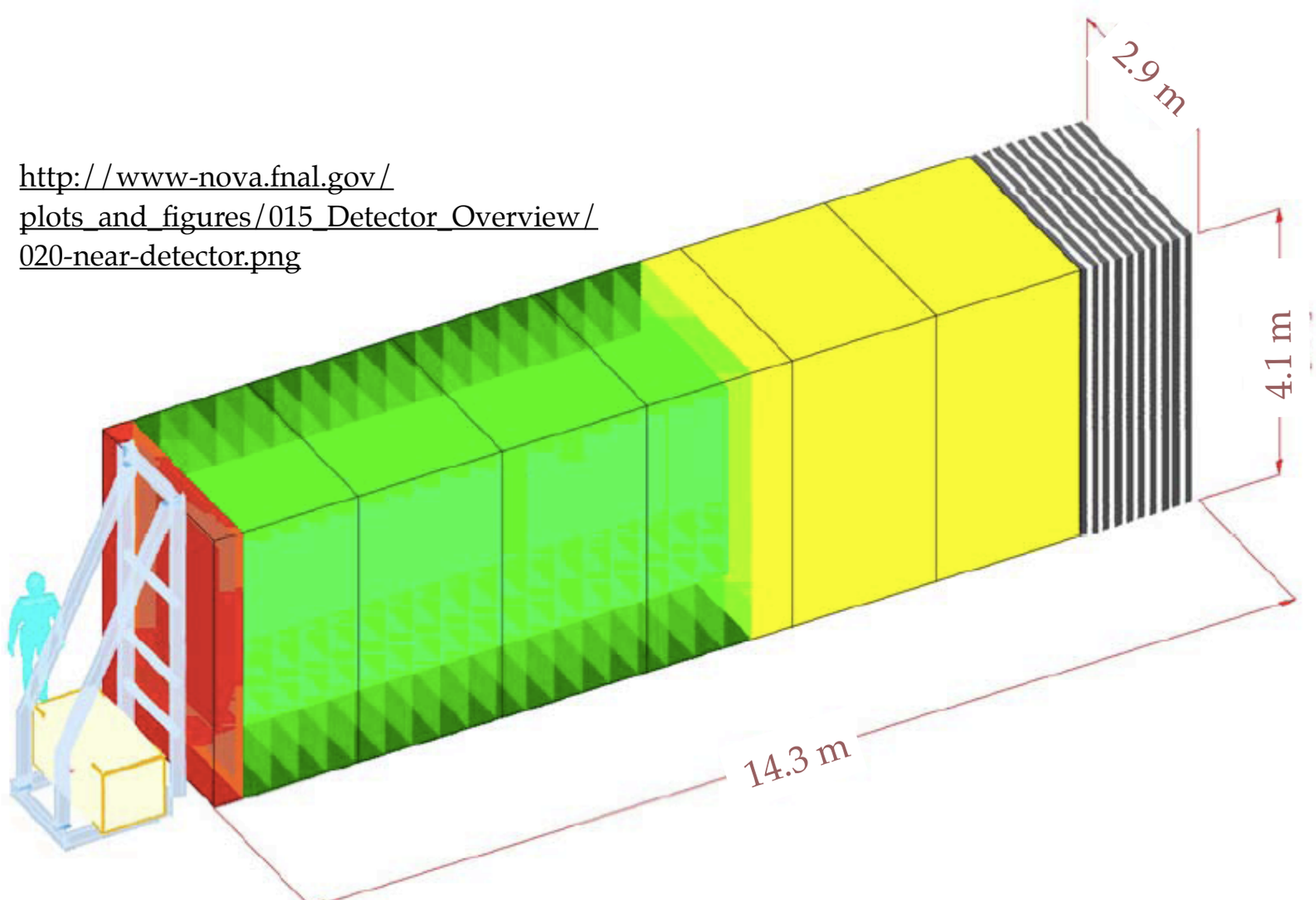


Near Detector

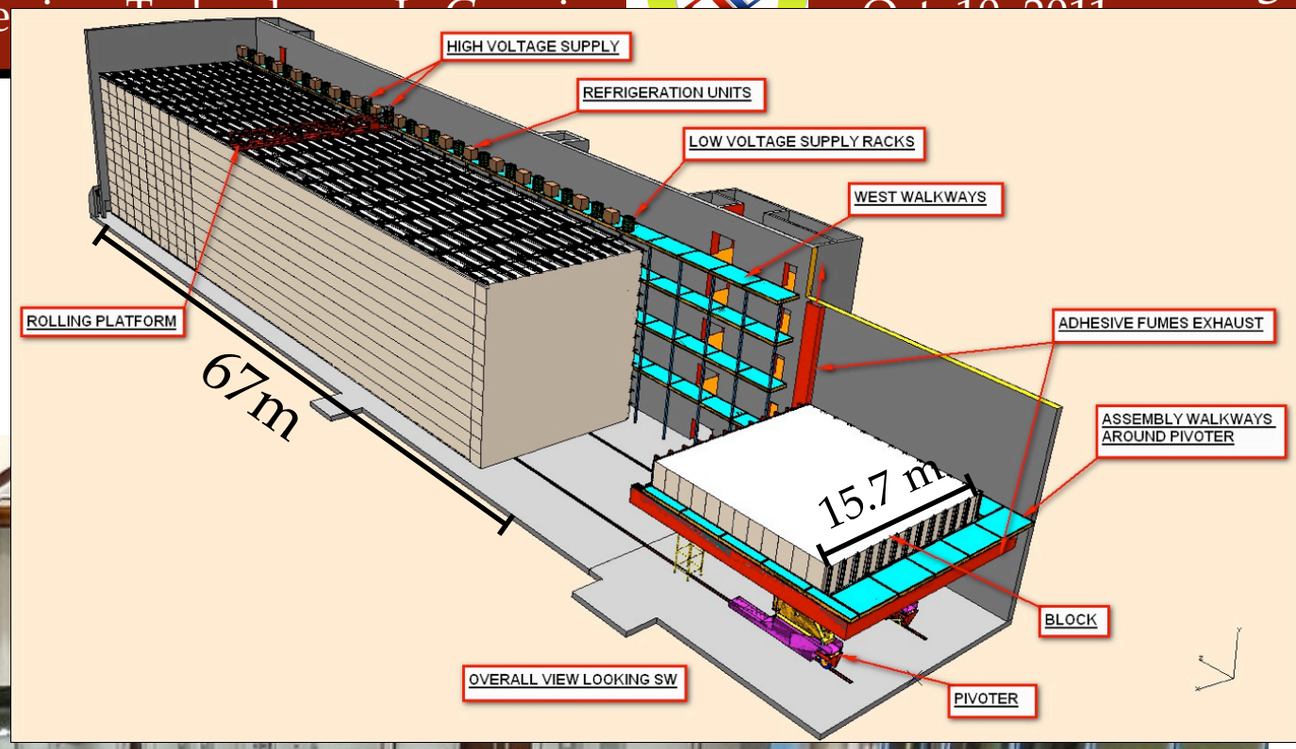
- 220 tons
- Will be placed in a new cavern in attached to the current MINOS cavern
- Characterize beam before oscillations



http://www-nova.fnal.gov/plots_and_figures/015_Detector_Overview/020-near-detector.png



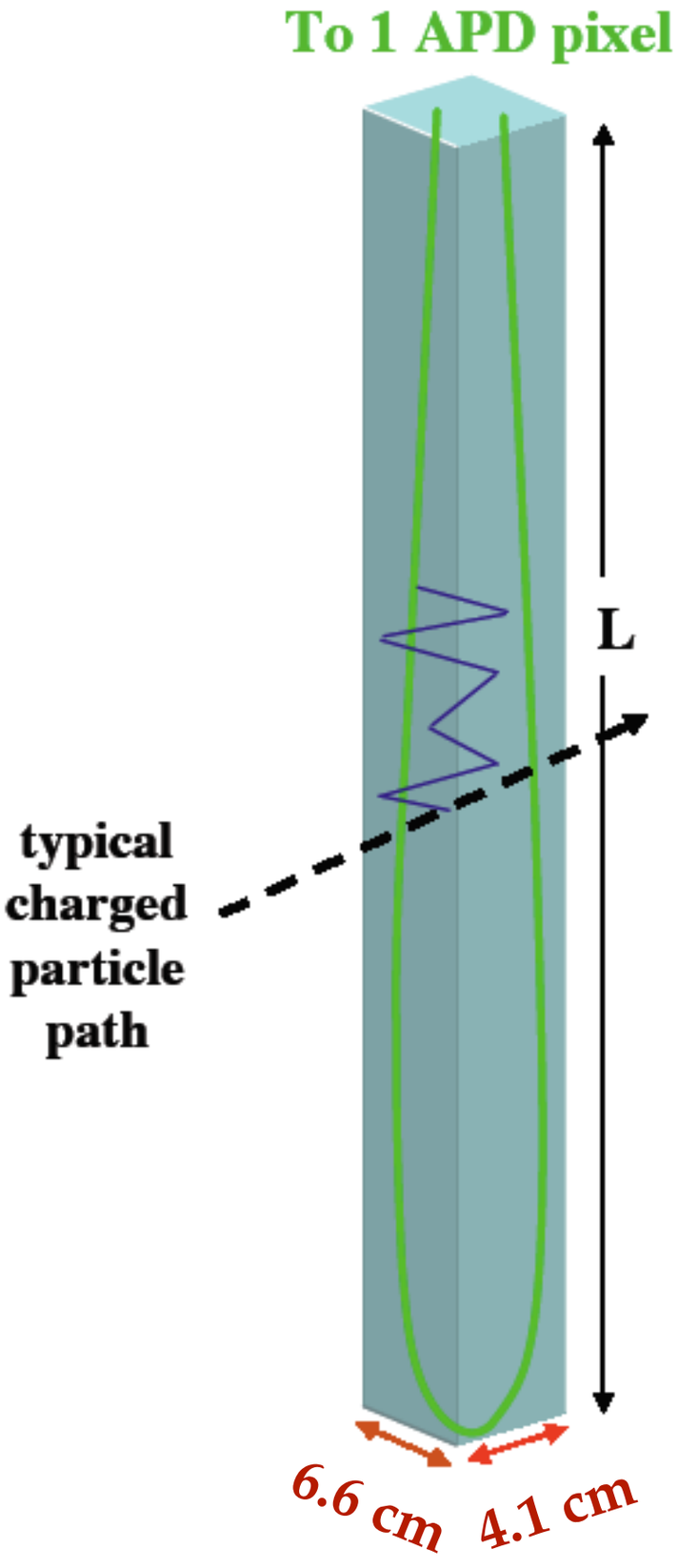
Far Detector Building

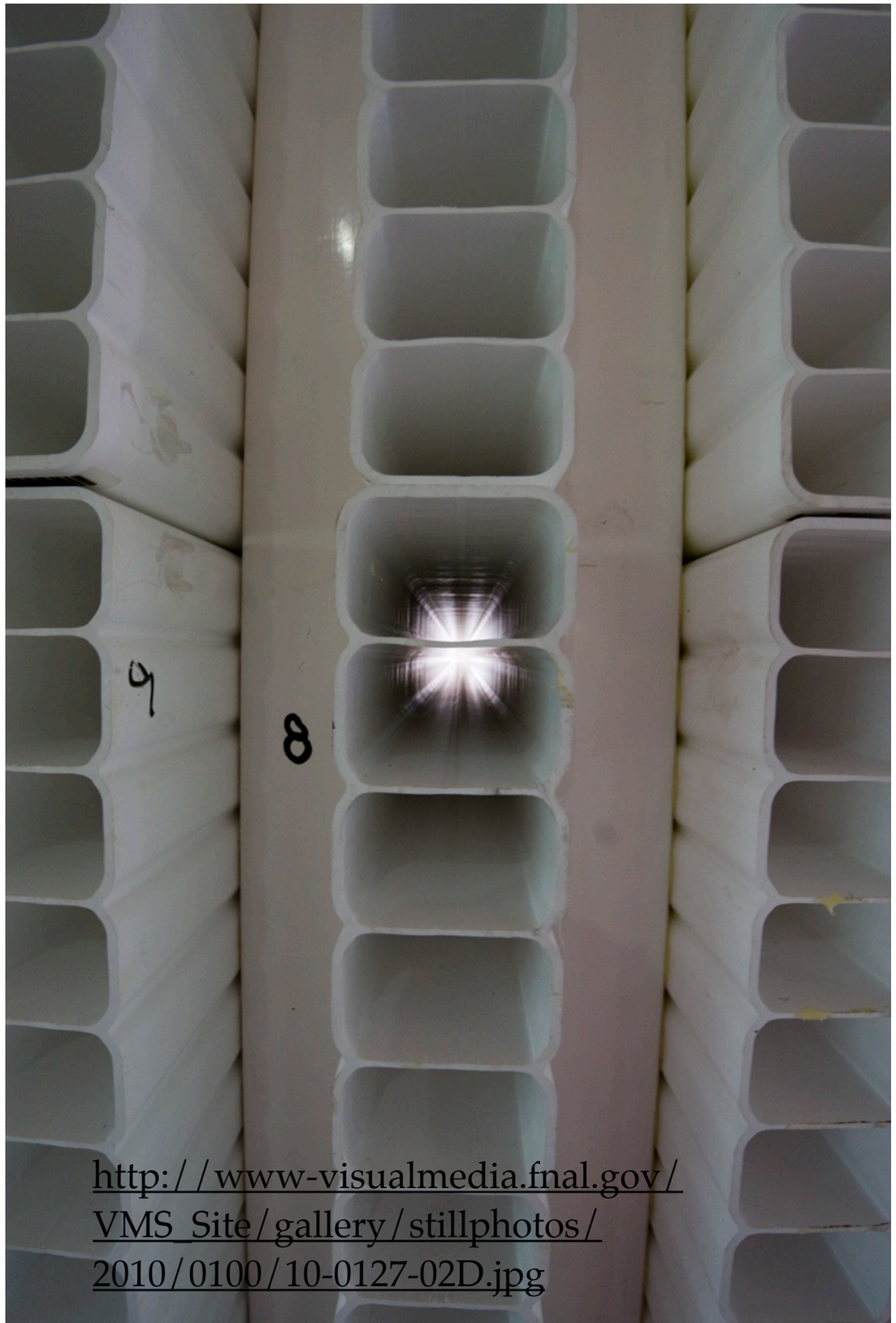


Near Detector On the Surface (NDOS)

- **Prototype** built to the original design of the near detector
- Instrumented, operational and taking data
- Results
  - Taught us many lessons
  - Enabled us to correct many bugs and flaws
  - Several design and procedure change

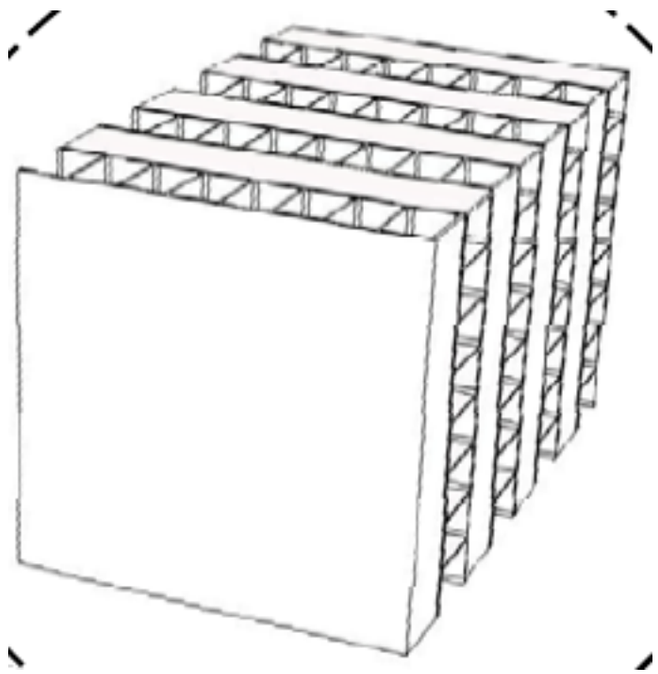
Detector Elements





http://www-visualmedia.fnal.gov/VMS_Site/gallery/stillphotos/2010/0100/10-0127-02D.jpg

- Cells with liquid scintillator grouped into alternating planes



Our Scintillator Recipe

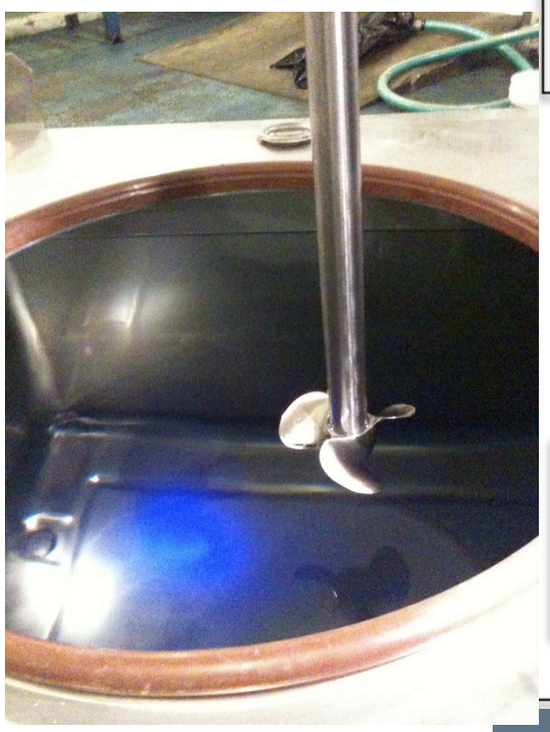
Liquid Scintillator

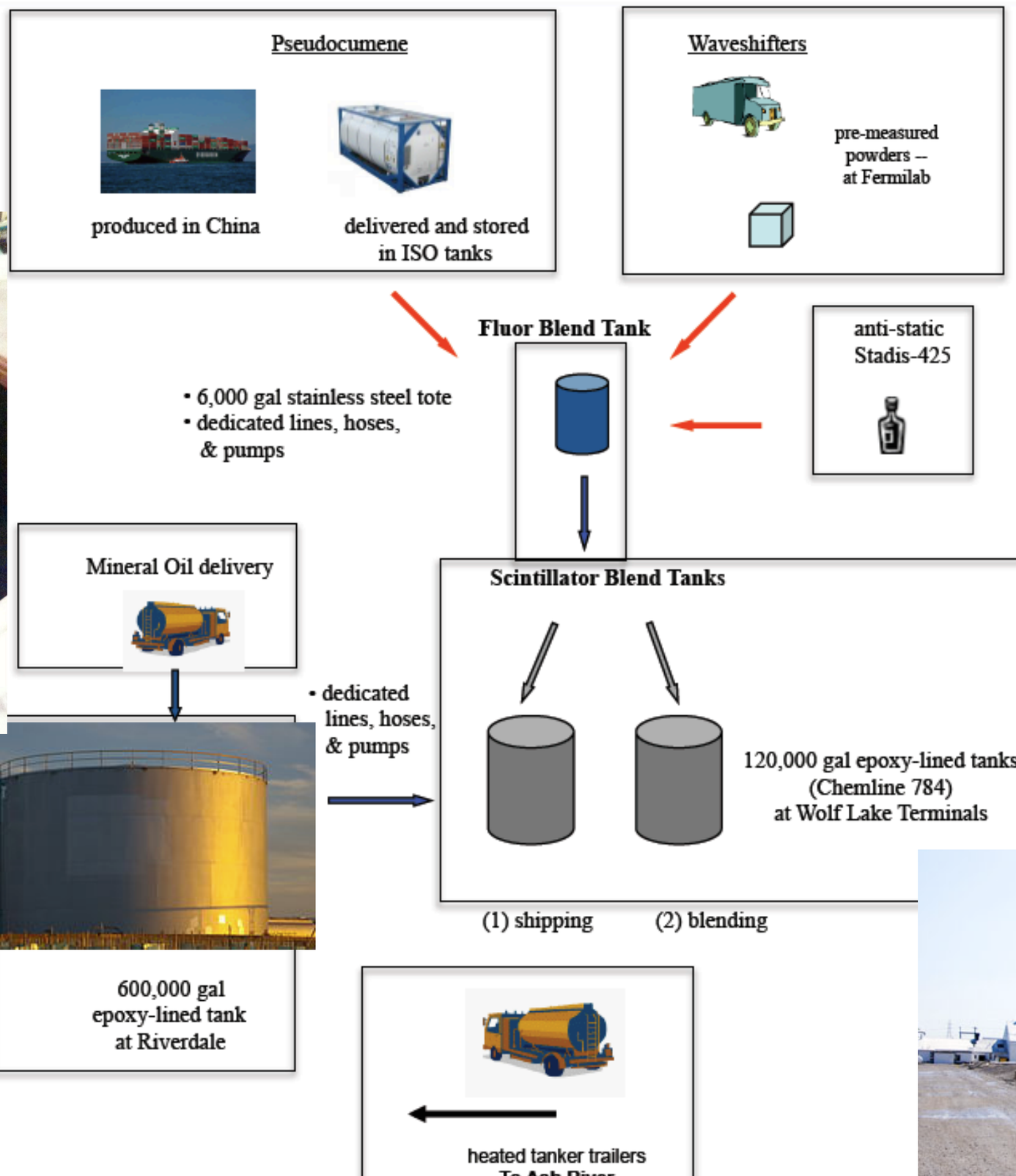
94.91% food grade mineral oil
4.98% pseudocumene (scintillant)
0.110% parts PPO (powder, wave shifter)
0.00153% bis-MSB (powder, wave shifter)
0.0010% Stadis-425 (anti-static)
0.0010% Vitamin E (antioxidant)

1. Mix PPO, bis-MSB, Stadis-425, and Vitamin E into pseudocumene to produce fluor blend.

2. Mix fluor blend into mineral oil to produce NOvA liquid scintillator

Mixing The Scintillator





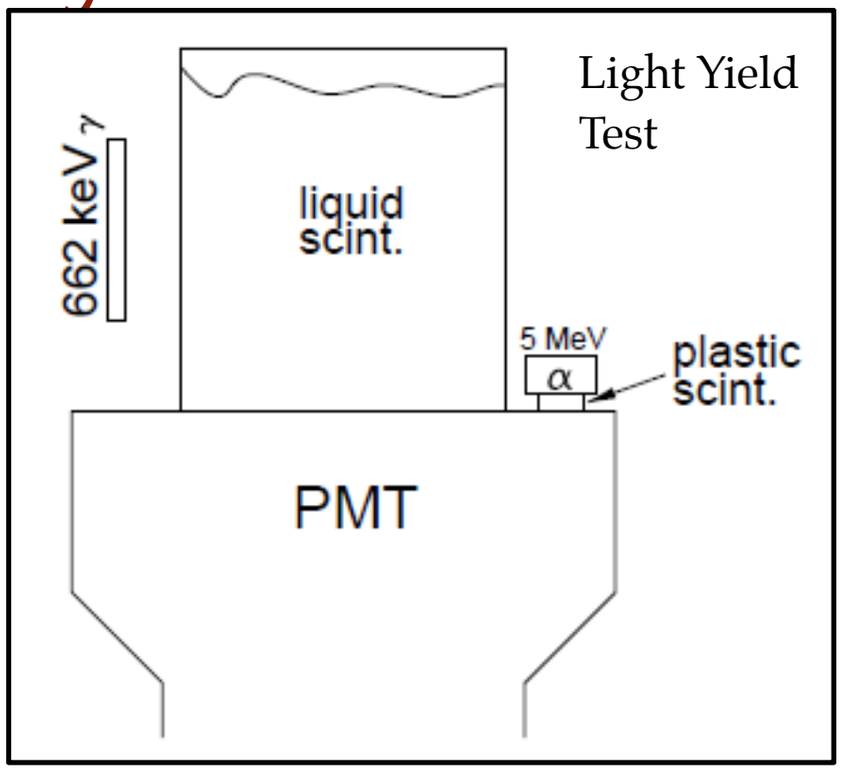
Have enough of everything except mineral oil and pseudocumene for 18kt far detector

Hired private contractor (Renkert Oil) to deliver mineral oil and mix ingredients

We currently have 300,000 gallons of oil in the tank.

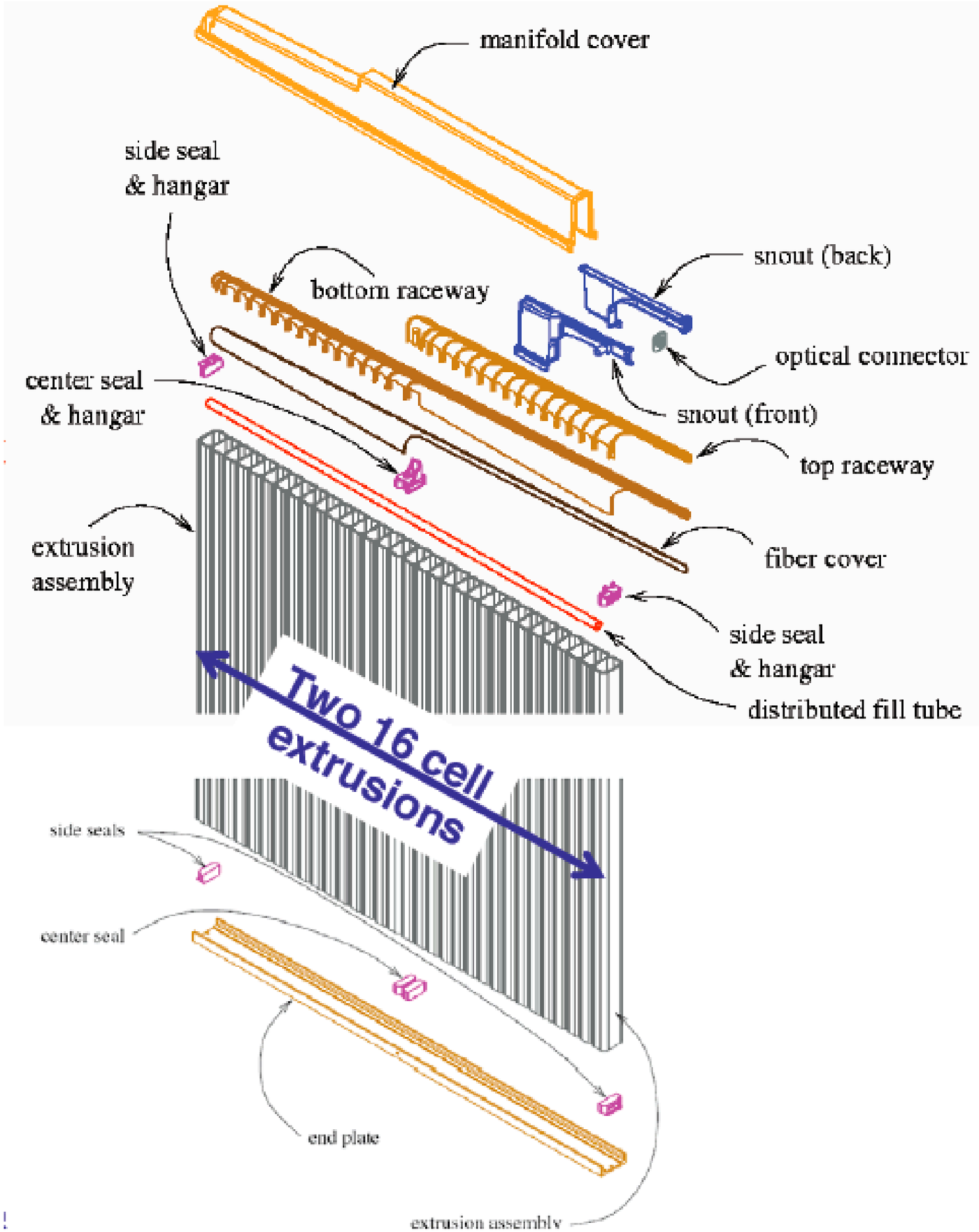
Scintillator Quality Control

- Light Yield
  - Use radioactive sources to verify sufficient scintillator light
- Clarity tested using a commercial tintometer
- Verify correct chemical composition.
  - Done at Indiana Univ. Chemistry Dept.



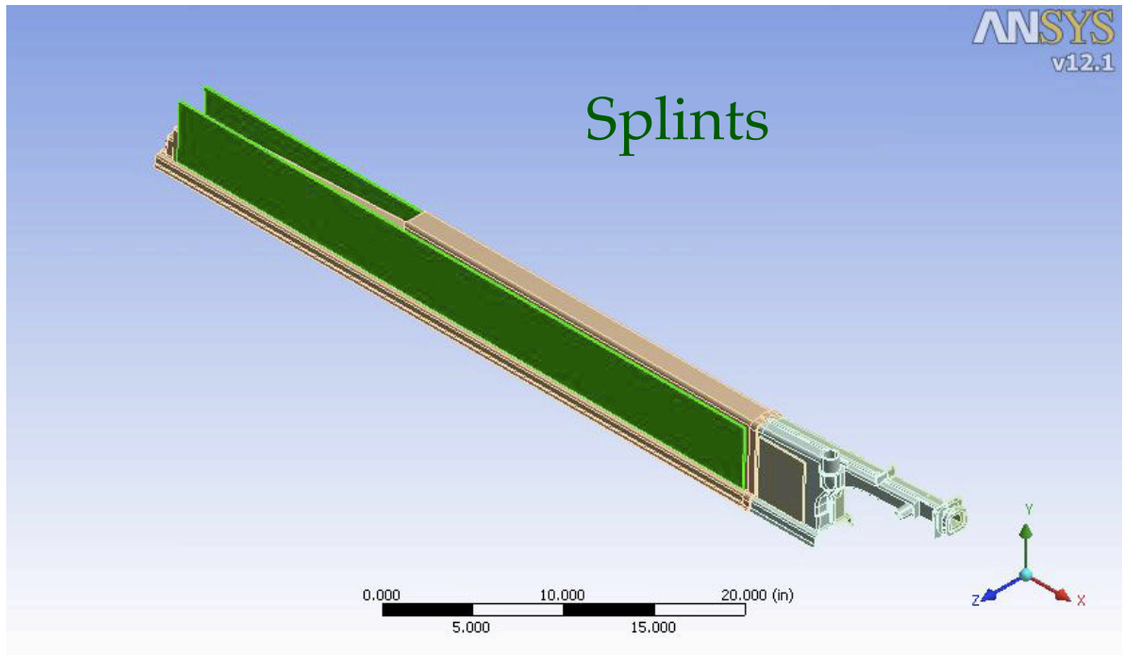
Module Assembly

- Many pieces must be brought together to form an active detector module
- Cell interiors must be very reflective so scintillation light is not lost.

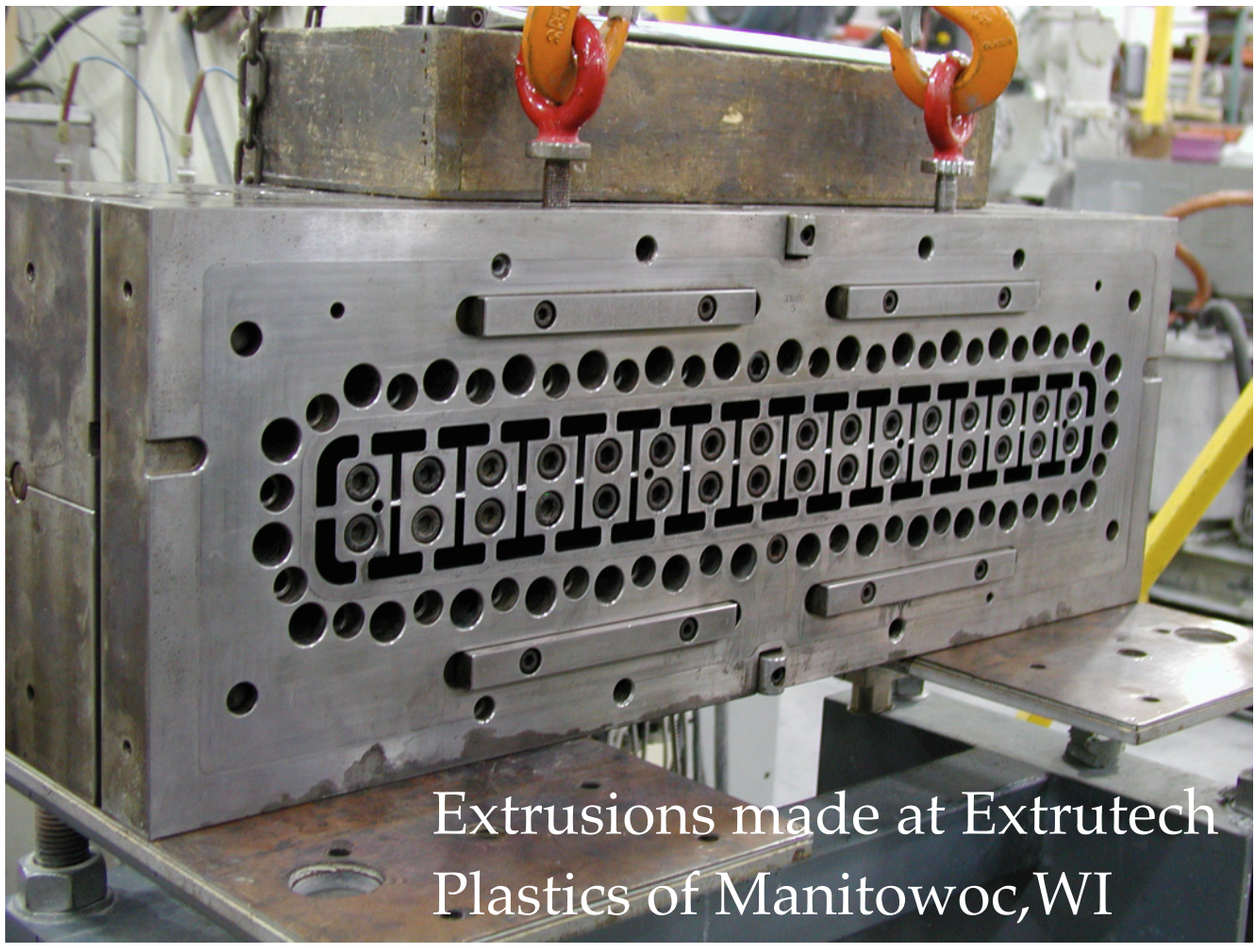


Manifold Issues

- Manifolds have developed cracks (22%)
  - Splinted the NDOS manifolds
  - Redesigned manifolds to remove stress points for near and far detectors



PVC Extrusions



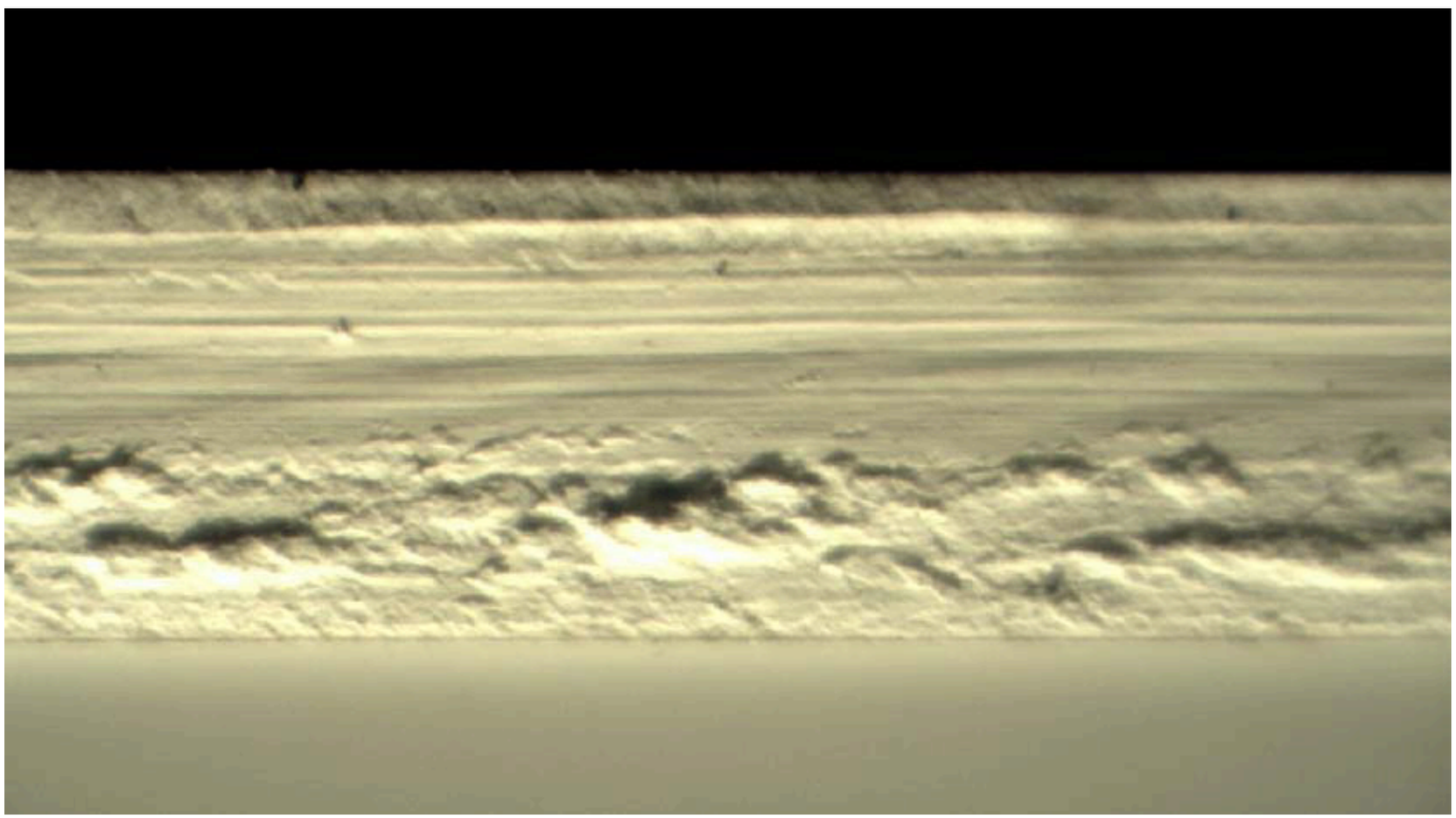
- PVC extruded through die to form 15m extrusions
- ~24,000 required for Far Detector.
- Currently have ~2300 useable modules in hand.

PVC Reflectivity Issues

- We require predicted light yield to the APD to be >14.6% of a perfect reflector.
  - Achieved using TiO_2 in PVC, which is produced in two forms: rutile and anatase.
- Low reflectivity in some batches correlated with high fraction of rutile
  - Requested <2% rutile contamination, and so far that is what we have received.

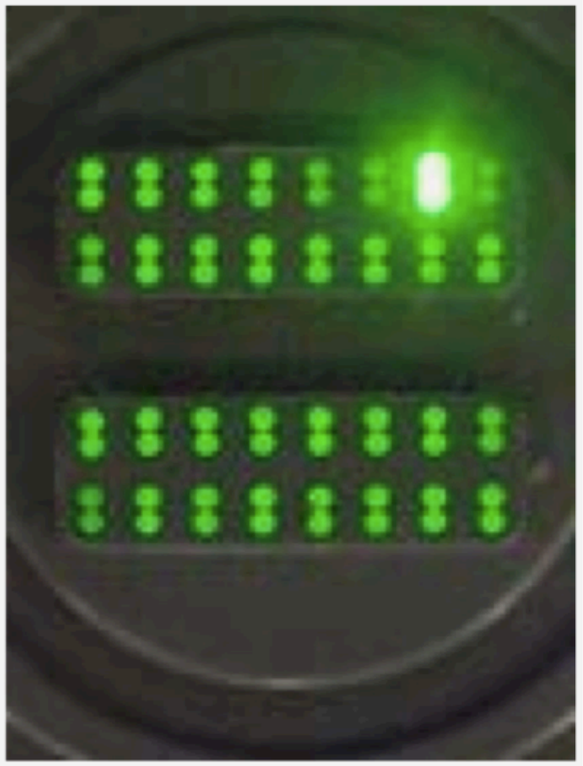
PVC knitting issues

- PVC not "knitting" well when extruded from die
  - Ongoing iterations with manufacturer greatly improving results
  - No voids found in extrusions, so they are still useable

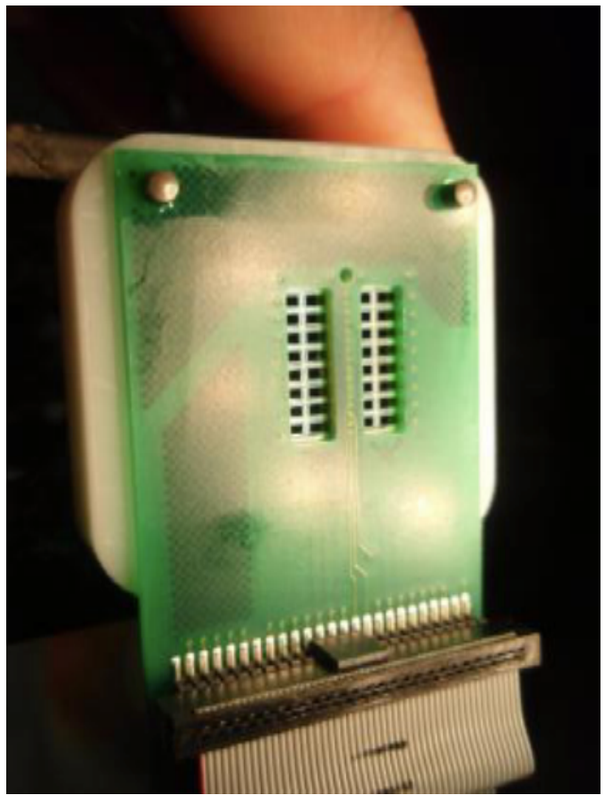


Extrusion samples are often cracked in QC testing, revealing smooth regions in the cross-section, such as the central region in this example, that are not well knitted.

Light Chain



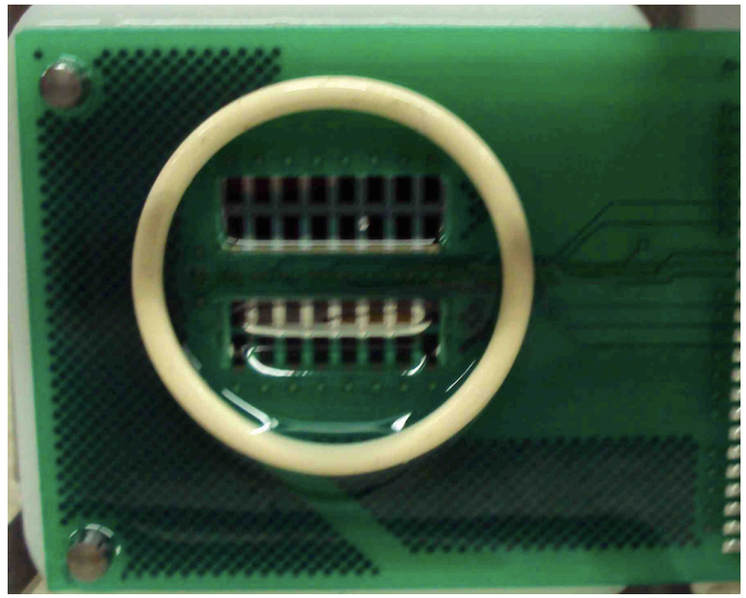
Scintillation light travels along wavelength shifting fibers to end of manifold

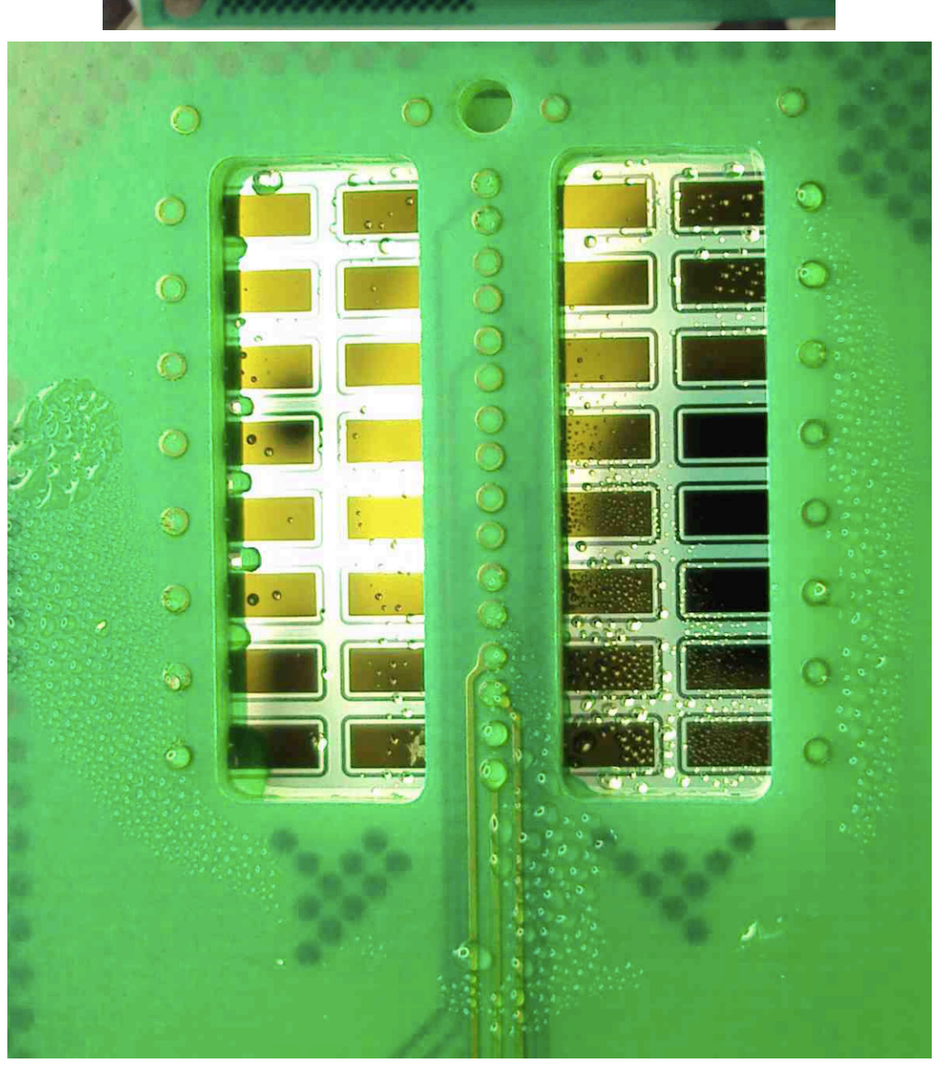


Light detected in by avalanche photodiodes (APDs) that are sealed, cooled (to -15 °C) and mated to the detector data acquisition system.

APD Noise Issues

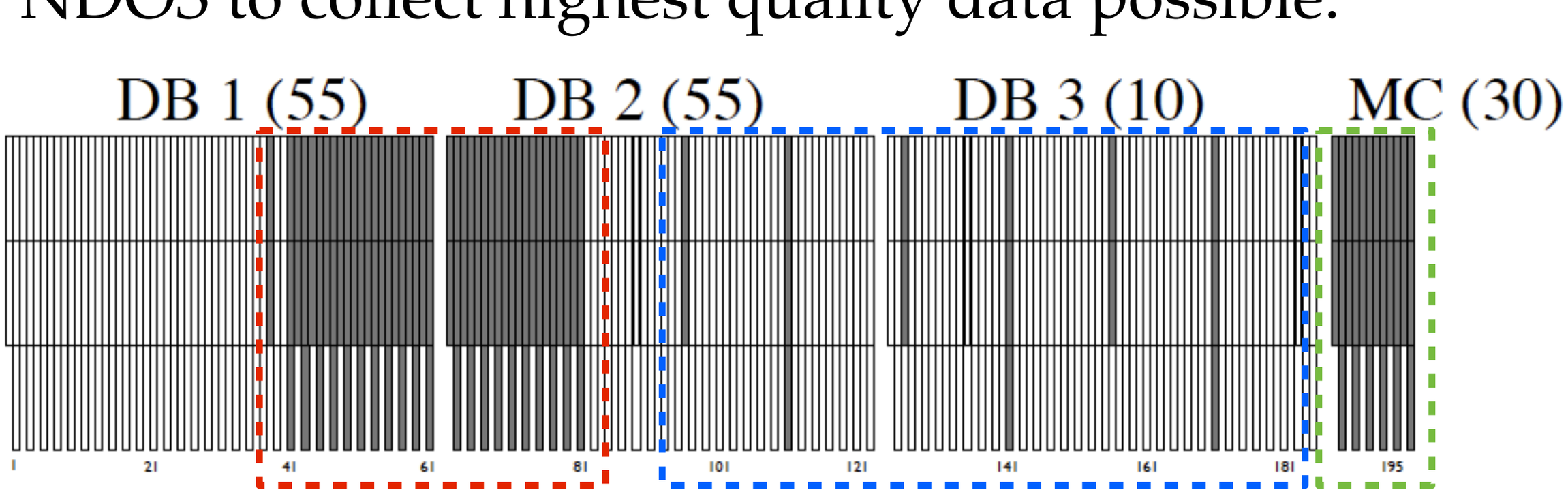
- We have received a total of ~420 APDs for the NDOS
  - ~150 of them are still working
- Failure modes
  - Dirt and oil
  - Corrosion
  - Contact with fibers
  - Water leaks (leading to ice formation when cooled)
  - Installation Errors
  - Possibly unknown modes





Preserving and Redistributing APDs

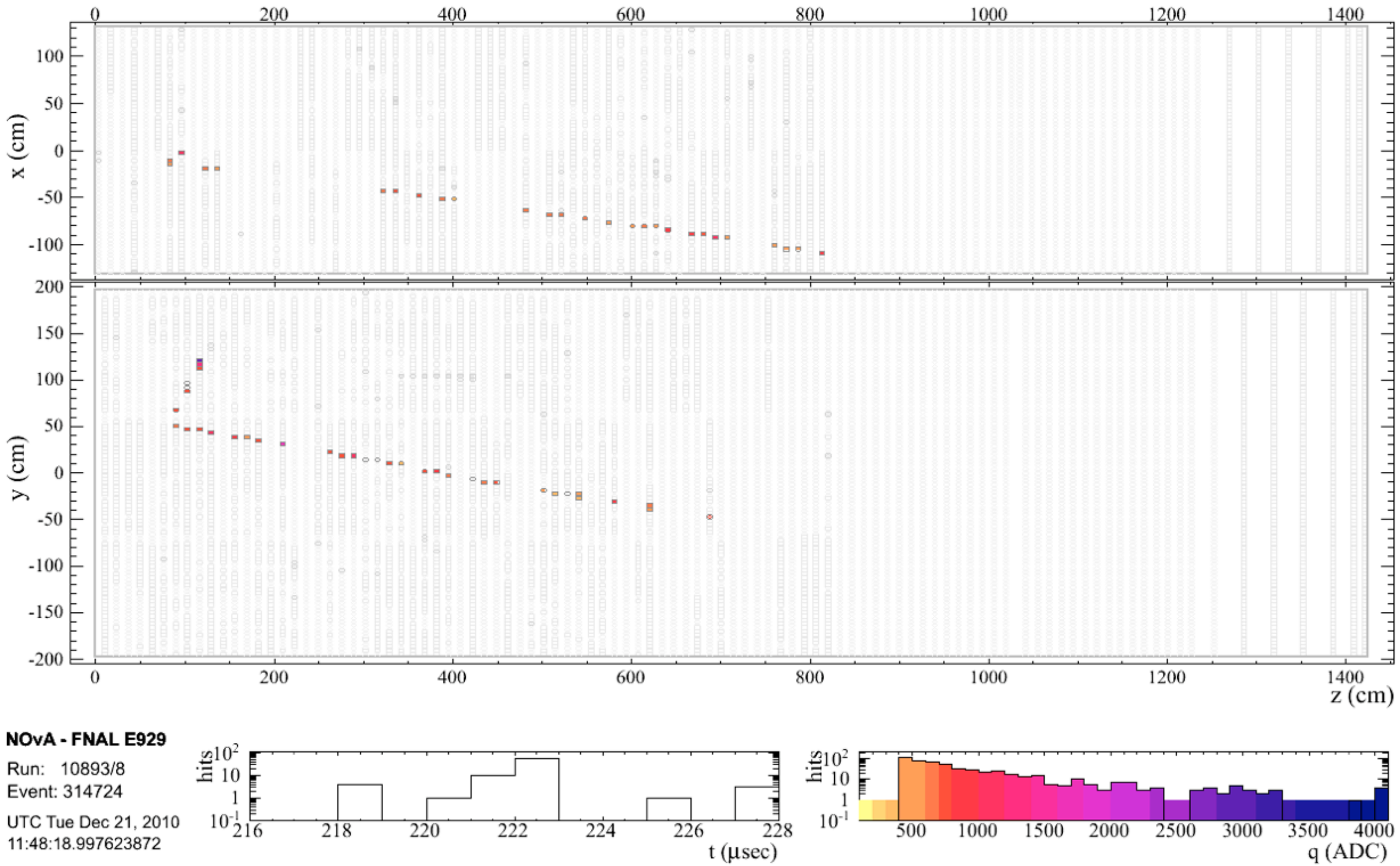
- Running remaining APDs without cooling to preserve them
- Have begun be rearranging surviving APDs on the NDOS to collect highest quality data possible.



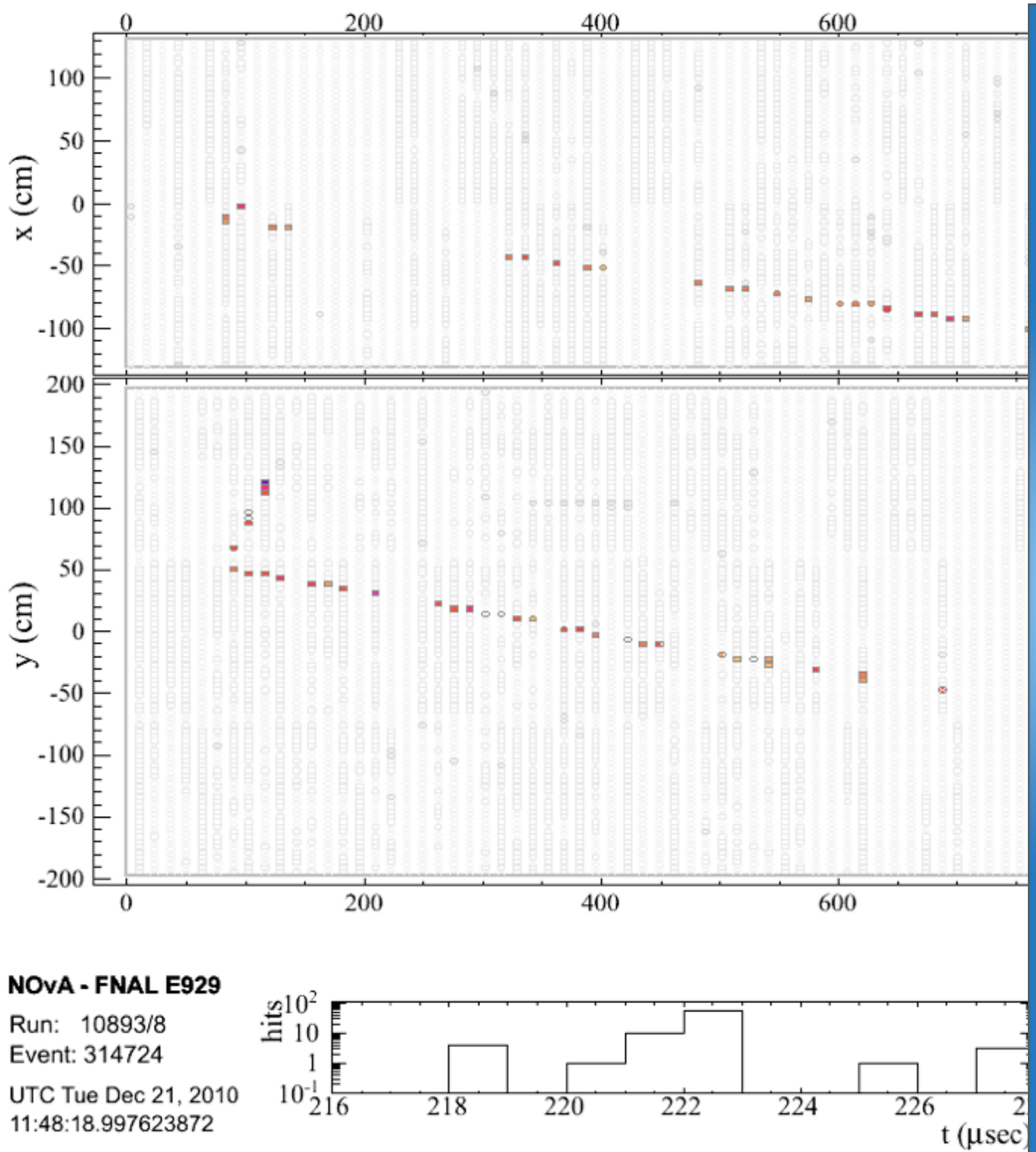
APD Potential Solutions

- "Cabel-ectomy"
  - Remove cable from noisiest pixel
  - Sometimes successful in reducing noise on neighboring pixels
- Coated APDs
  - Did not order APDs with coating because the standard coatings produced optical cross-talk
  - In discussions with manufacturer to produce APDs with protective coatings that will avoid cross-talk
  - Testing coatings of our own (silicone and parylene) on APDs on NDOS
- Attempting to clean/repair some of the non-functioning APDs

First Data!

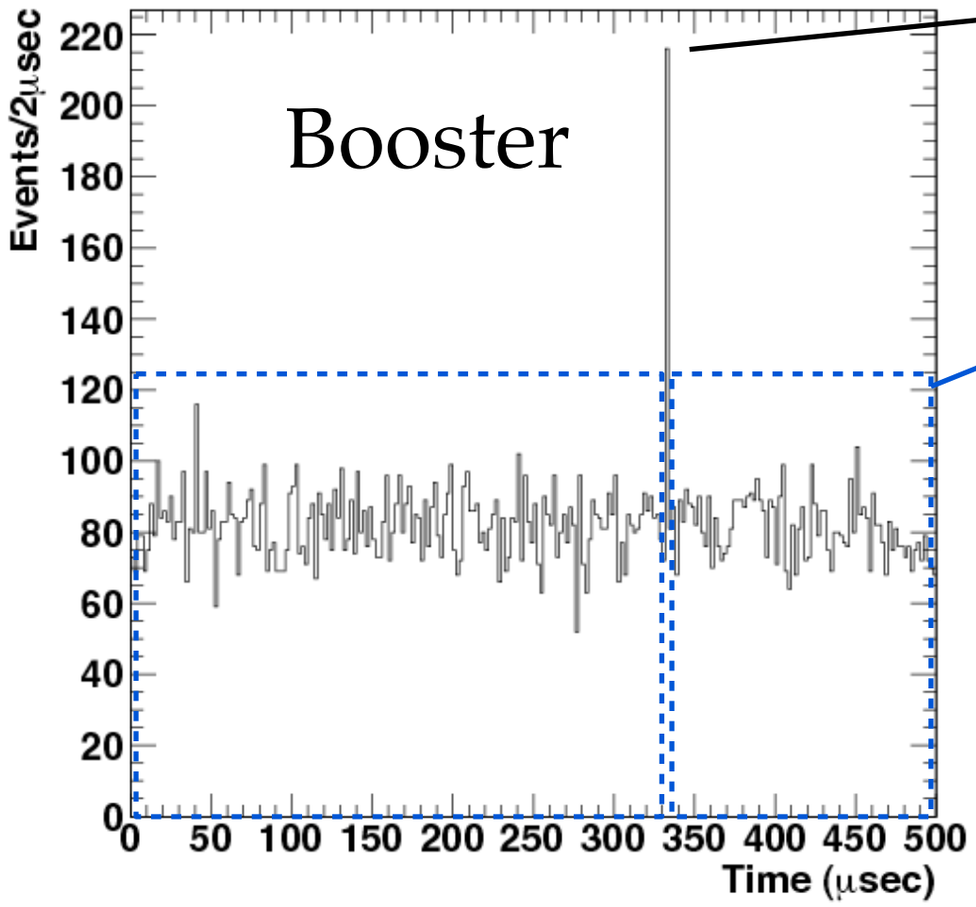

x (cm)
y (cm)
z (cm)
NOvA - FNAL E929
Run: 10893/8
Event: 314724
UTC Tue Dec 21, 2010
11:48:18.997623872
hits
t (μsec)
q (ADC)

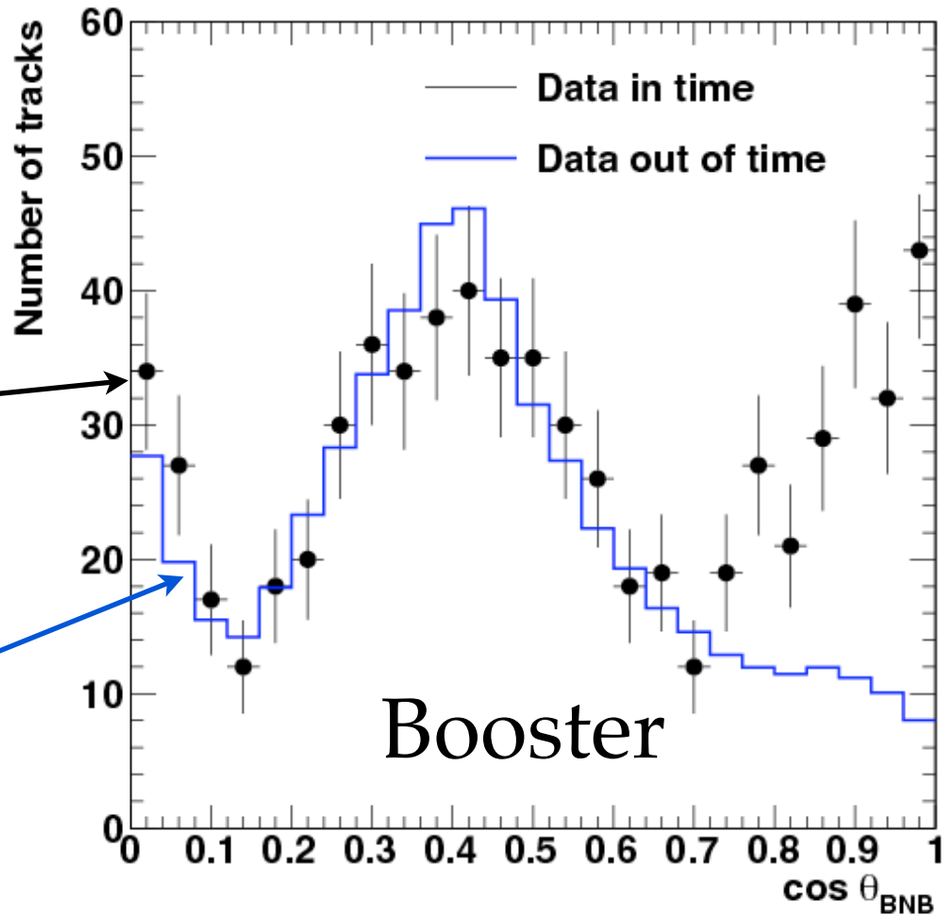
First Data!


x (cm)
y (cm)
0
200
400
600
-200
-150
-100
-50
50
100
150
NOvA - FNAL E929
Run: 10893/8
Event: 314724
UTC Tue Dec 21, 2010
11:48:18.997623872
hits
t (μsec)

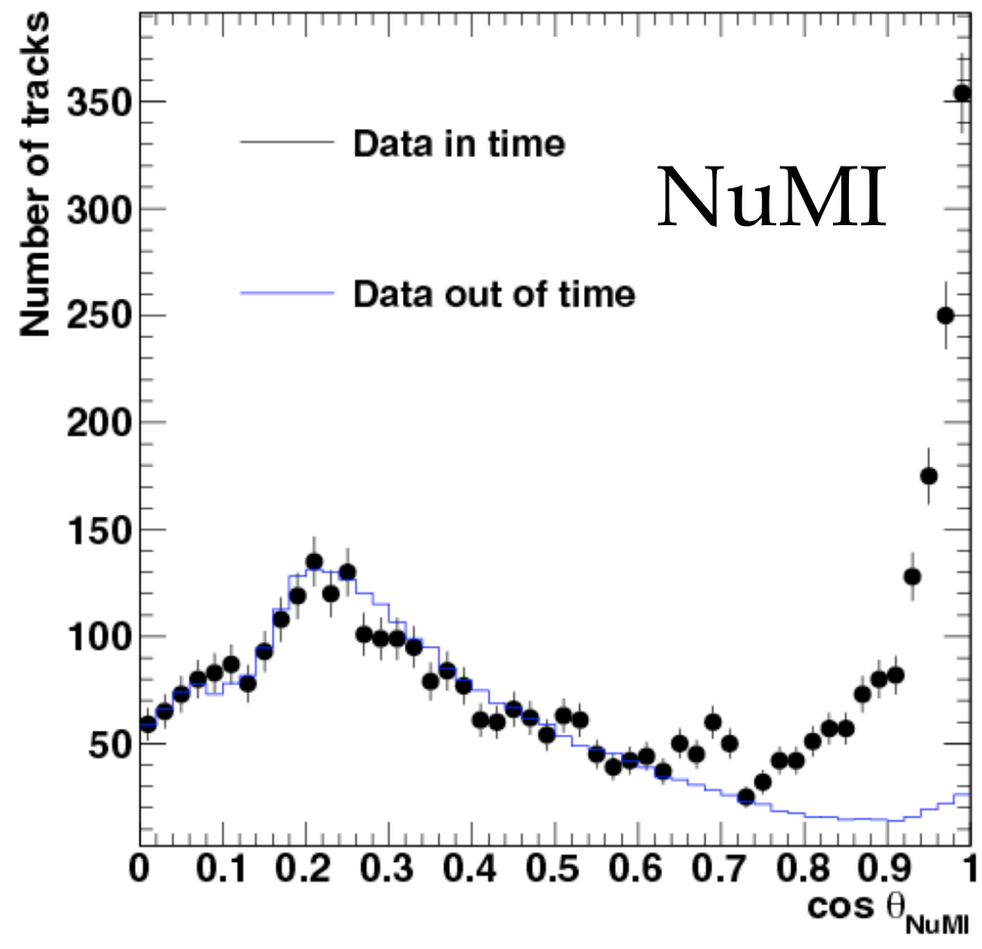

Season's greetings
from the
NOvA collaboration
A cosmic ray shower
Our first neutrino

Finding the Beams





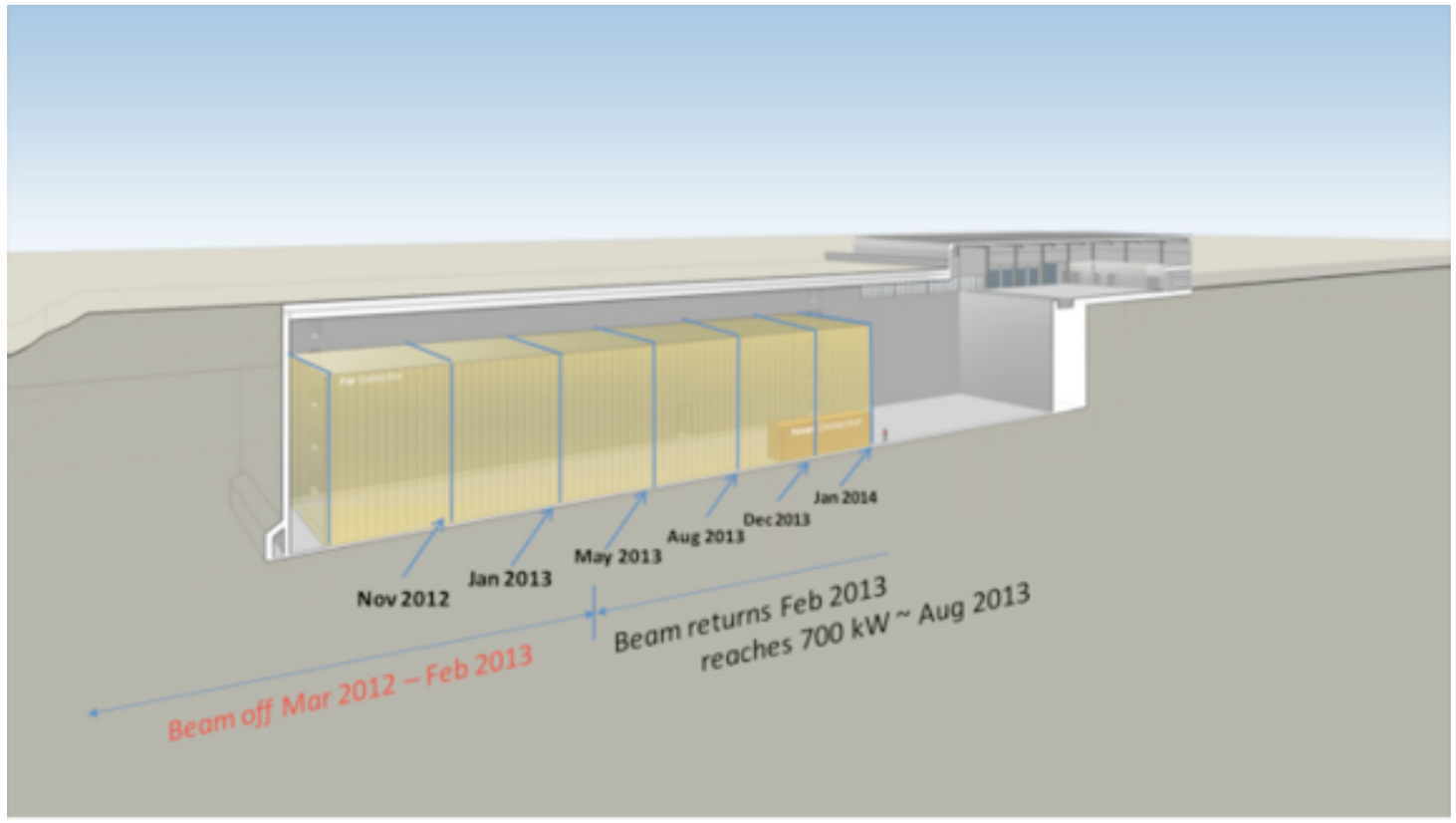
http://www-nova.fnal.gov/plots_and_figures/070_NDOS_BNB_Events/10-cosbnb.png



http://www-nova.fnal.gov/plots_and_figures/060_NDOS_NuMI_Events/10-costheta-numi.png

Schedule

- Tevatron shutdown on Sep. 30, 2011
- First large scale fluor blend Oct. 12
- FD construction at Ash River site begins Jan. 2012

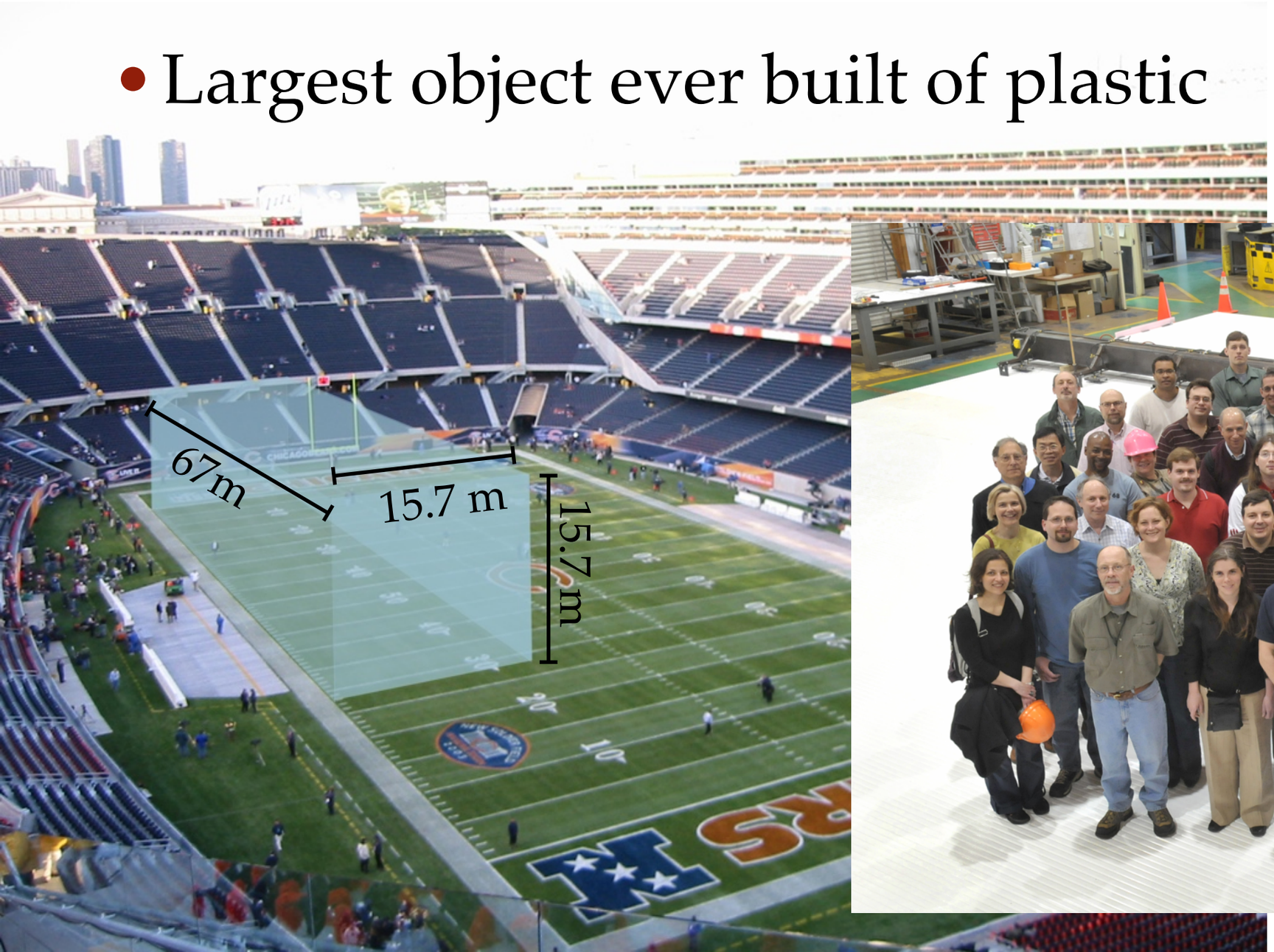


- FD finished in early 2014
- Accelerator shutdown Mar. 2012
- NOvA beam turns on Feb. 2013
- ND cavern excavation during accelerator shutdown

Backup

Far Detector

- 14,000 - 18,000 tons
- Will detected oscillated beam
- Largest object ever built of plastic



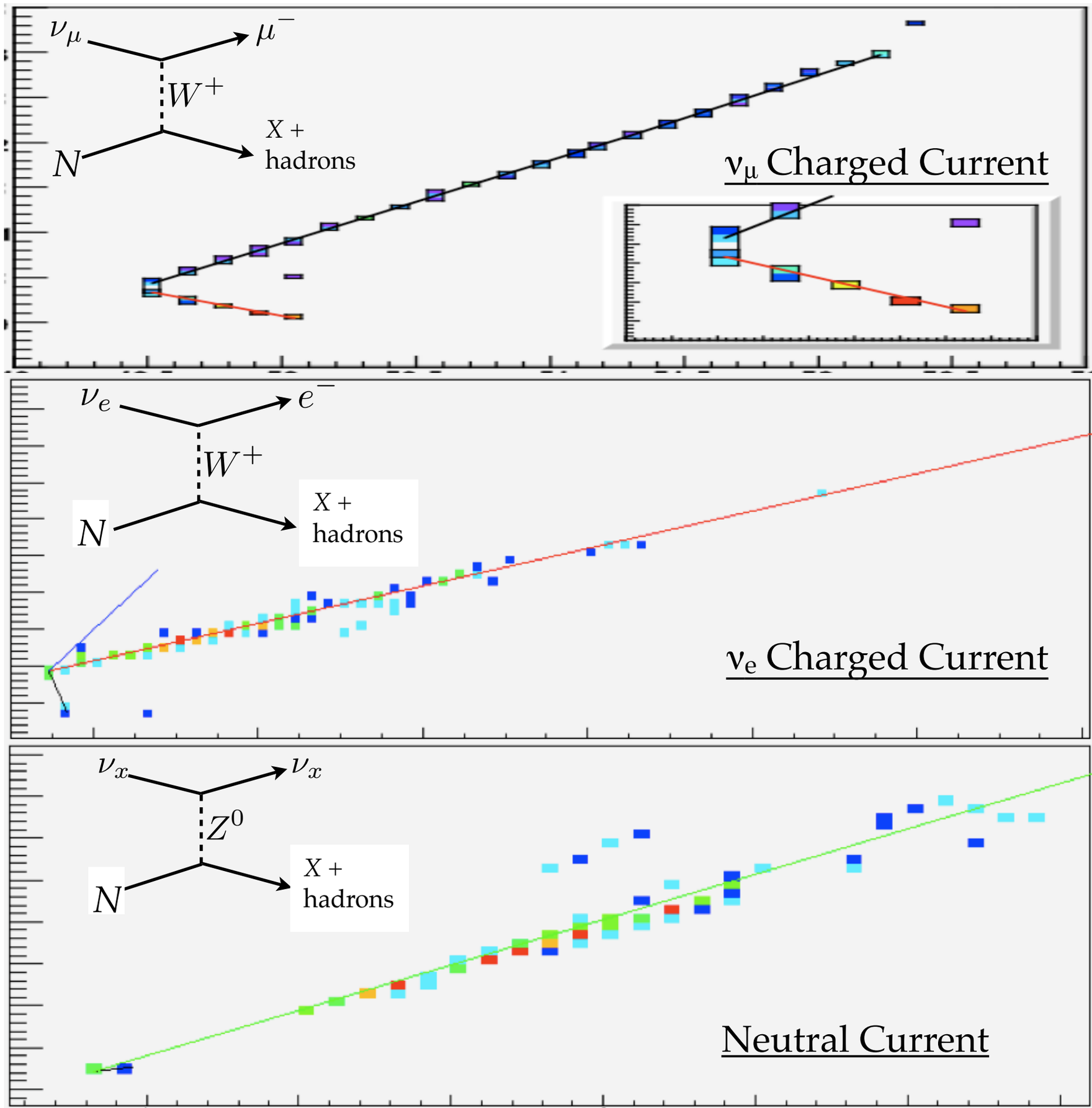
Quality Control

- Light Yield
  - Use radioactive sources to verify sufficient scintillator light
- Chemistry
  - Verify correct chemical composition.
- Clarity (15 m long far detector cells)
  - Use a “tintometer”
  - Maintaining cleanliness critical at every stage!

This is what we found when we looked inside of one of the fluor blending totes for the NDOS. The green substance was not identified (my guess was Mountain Dew). It was thoroughly cleaned by the blending company before any scintillator components were added.

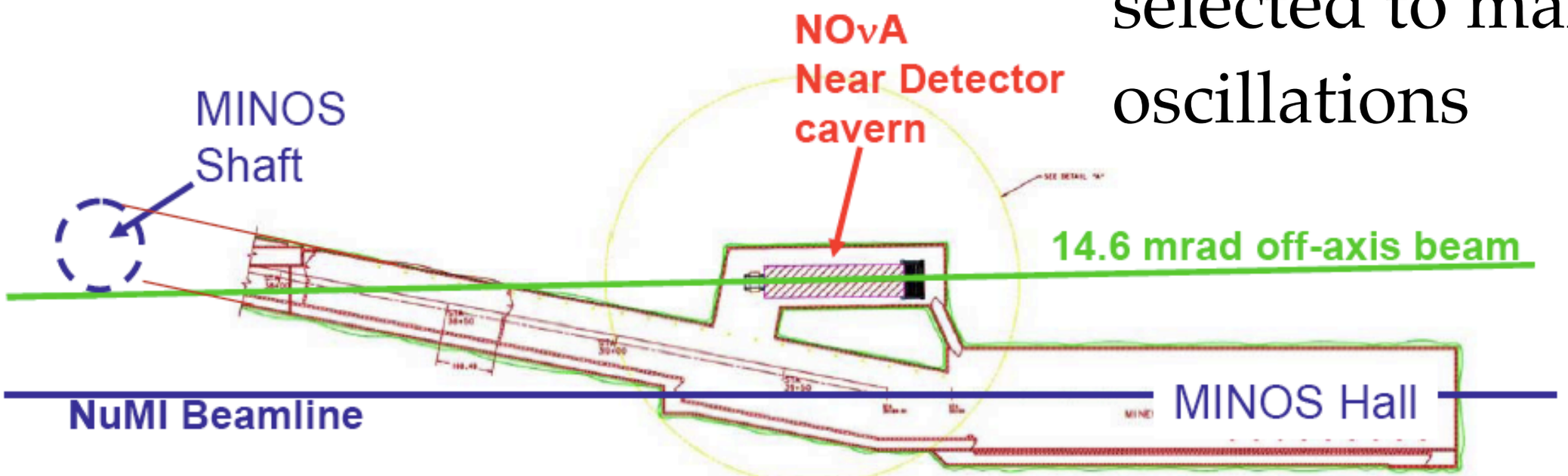
Neutrino Interactions

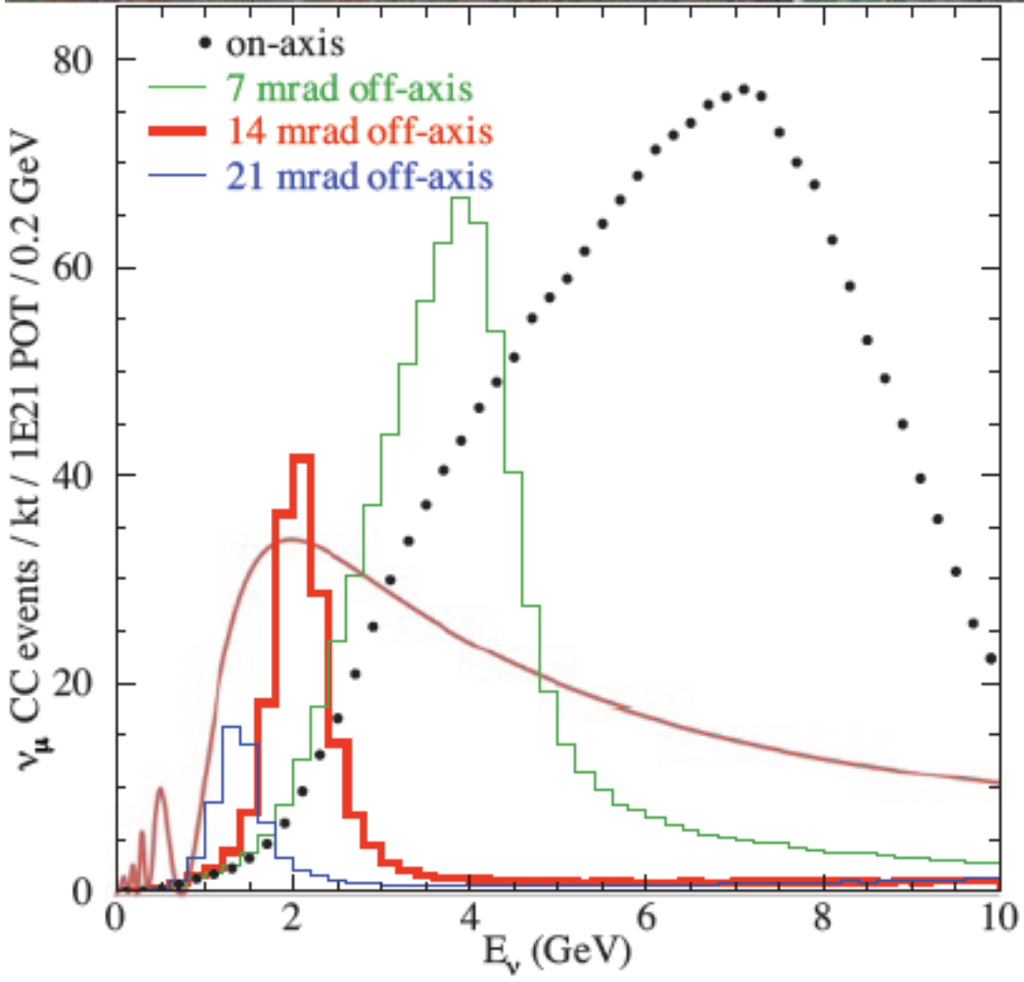
- Like the wind, you can't see neutrinos, but you can see their effects.
- Simulated events at right

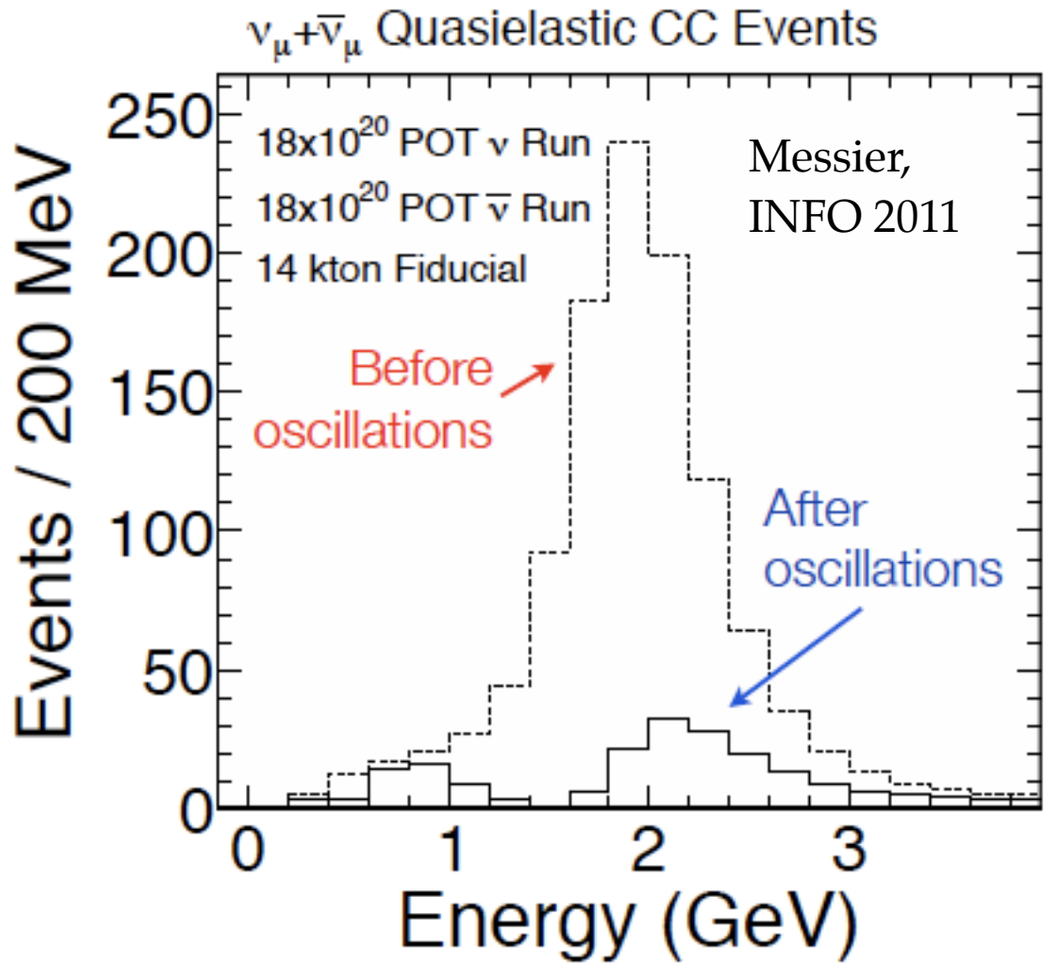


Off-axis

- Baseline (L) and E selected to maximize oscillations







Filling

- NDOS is filled with high-quality scintillator
- Pumping and piping systems being developed for Far Detector
- 6 tankers per week to Far Detector planned
- ~3,000,000 gallons

The NuMI Beam

- Small Cross section ⇒ we need large number of neutrinos ⇒ we need an intense beam